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Dat Mailed: July 3, 2003

UNITED STATES PATENT APPLICATION FOR GRANT OF LETTERS PATENT

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METHOD AND APPARATUS FOR TOWER REINFORCEMENT SYSTEM

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METHOD AND APPARATUS FOR TOWER REINFORCEMENT SYSTEM

BACKGROUND OF THE INVENTION

[0001] The present invention generally relates to towers, such as those used for radio and television communications, and particularly relates to reinforcing pre-existing towers.

[0002] Antenna towers are commonplace fixtures that stand in silent testament to the proliferation of modern communication systems. Many types of towers exist, including monopole, freestanding structural, and guyed structural towers. Intended use, geographic area, and physical site details all drive the particular type of tower selected. However, substantially common concerns drive the selection and design of all such towers.

[0003] These concerns include both practical and safety-of-design concerns. For example, TIA/EIA-222-F is a controlling standards document for structural steel antennas. Among other things, the standard specifies combinations of wind and ice loads that towers must withstand. These loading requirements vary by geographic location. As might be expected, wind load requirements tend to be higher for certain coastal areas as compared to relatively more sheltered inland regions. Similarly, ice load requirements tend to vary geographically.

[0004] Further, various local ordinances may impose specific tower loading and safety requirements that exceed or add to the TIA/EIA-222-F reference standards. For example, a given city may modify its applicable building codes to raise tower wind and/or ice load requirements incrementally over several years in recognition of the growing importance of tower safety as more and more towers are installed in increasingly urban areas.

[0005] Interestingly, many such code changes include "grandfather" clauses exempting pre-existing towers from the increased load requirements. However, such grandfather clauses usually are lost if any tower modifications are made to a pre-existing tower. Tower owners often face the dilemma of either not upgrading an existing tower to avoid the new requirements or replacing the existing tower with a new, stronger tower to meet the revised code requirements.

[0006] Event without the problems associated with increasingly rigorous standards, existing towers may be problematic because of their inability to carry additional equipment while still meeting the applicable standards. This inability to get more use from each tower particularly is problematic in built-up areas with limited tower locations. In extreme cases, a service provider may be prevented from entering a given local market because of the inability to add the necessary additional equipment, such as new antenna assemblies and associated antenna "feed" lines, to the tower antennas providing service coverage to that market.

SUMMARY OF THE INVENTION

[0007] The present invention comprises a method and apparatus for reinforcing existing towers. In one or more embodiments of the present invention, an exemplary reinforcing assembly includes a plurality of reinforcing legs and corresponding braces. Essentially, the reinforcing legs and braces form a reinforcing structural network that surrounds at least a portion of the existing tower. By attaching the reinforcing structural network with the existing tower, the network shares loads with the existing tower. For example, by attaching the reinforcing structural network to tower legs, such as at leg section joints, the network shares tower loads transferred through the existing tower legs.

[0008] Thus, for an existing tower having a series of sections stacked one over the other, with each section including a series of legs and wherein there is provided joints between respective legs of adjacent sections, an exemplary assembly comprises a plurality of reinforcing legs, with each reinforcing leg mounted adjacent a leg of a section and interposed between a pair of joints such that the reinforcing leg caries compression and tension loads. The exemplary assembly further comprises a plurality of braces, with each brace connected to and extending between a pair of reinforcing legs, such that the plurality of reinforcing legs and braces form a reinforcing structural network that extends around at least a portion of the existing tower.

[0009] In accordance with the above exemplary assembly, an exemplary reinforcing method comprises mounting the reinforcing legs between pairs of section joints of tower legs in one or more sections of the existing tower such that the reinforcing legs mount adjacent to and share tower

loads with the legs of the existing tower. The reinforcing method further may comprise bracing the mounted reinforcing legs by interconnecting pairs of reinforcing legs within each reinforced section of the existing tower with one or more cross braces. Cross bracing pairs of reinforcing legs increases the bending and torsion strength of the tower in each reinforced section of the tower.

[0010] An exemplary reinforcing leg mounts adjacent a corresponding tower leg section by attaching to section joints at either end of the tower leg section. Thus, in an exemplary configuration, each reinforcing leg comprises a rigid leg having bearing plates attached to each leg end. These bearing plates include receiving slots to at least partially receive a tower leg and thereby permit the bearing plates to be positioned over tower leg flanges at the section joints.

[0011] By aligning with the abutting leg flanges that form a section joint between consecutive tower leg sections, the reinforcing legs on those adjacent leg sections are bolted together with the section joint, such that tower loads transferred through the section joint are shared by the reinforcing legs. A further advantage of this reinforcing leg configuration is that each bearing plate may be configured to cover a subset of the flange bolts in a section joint. Thus, the bearing plates of reinforcing legs on consecutive sections of a tower leg can be bolted together with the section joint joining the leg sections without completely unbolting the section joint. As such, reinforcing legs can be added to the existing tower without relieving tower loads and without compromising tower safety.

[0012] Additionally, the reinforcing legs may be configured to include one or more shim joints as needed or desired. By including shim joints in the reinforcing legs, the length of a reinforcing leg to accommodate variations in the distances between section joints in the tower legs. In other words, the reinforcing legs may be configured to span nominal section lengths of the tower legs, e.g., 5 ft., 10 ft., 15 ft. or 20 ft. section lengths, and then adjusted during installation by adding or removing shim plates to the shim joints.

[0013] Similarly, the cross braces may be configured such that each cross braces includes an adjustable-length bracing member that adjusts the span of each cross brace. In exemplary embodiments, the adjustable-length bracing members include adjustable sleeve nuts to

accommodate variances in the nominal span between reinforcing legs on different tower faces and along different sections of the tower.

[0014] Adding further installation flexibility, the reinforcing legs may be configured to bypass existing obstructions on the tower legs as needed or desired. For example, a reinforcing leg may include one or more section gaps separating individual sections of the reinforcing leg. Rigid bridging members interconnect the individual leg sections, while leaving an opening for an obstacle to be bypassed, may span these section gaps. In an exemplary alternate embodiment, leg reinforcing members may be formed with openings, notches, slots, etc., as needed or desired to avoid obstacles on the tower legs.

[0015] The reinforcing legs may be configured as channeled members that at least partially fit around the tower legs such that each reinforcing leg provides mounting faces on either side of the tower leg to which it is mounted. With this configuration, each reinforcing leg provides mounting faces on adjacent tower faces. These mounting faces, which may include one or more rows of mounting holes, provide mounting points for new and pre-existing tower appurtenances. Indeed, the reinforcing assembly may include one or more structural mounts to permit mounting new and pre-existing tower appurtenances to the reinforcing legs rather than to the tower legs. Exemplary mounts include, but are not limited to guy pull-offs configured to mount to the reinforcing leg mounting faces, and similarly configured boom gate mounts, which may be used to relocate existing boom gates to the newly mounted reinforcing legs.

[0016] The reinforcing assembly also may include one or more other reinforcing members, such as base reinforcing legs included in a bottom kit configured to reinforce the bottom sections of towers, which may comprise inverted pyramids terminating in a pivoting base plate. As such, the exemplary bottom kit is configured to interconnect with a bottom most set of reinforcing legs such the shared tower loads transferred down through successive sections of reinforced tower are directed into and shared between the existing tower base and the mounted base reinforcing members.

[0017] Additionally, it should be understood that the present invention may be used with single-section (or non-sectioned) towers. In such embodiments, reinforcing legs may be positioned consecutively along each tower leg, and bolted together at their abutting bearing plates to form an extended reinforcing leg running adjacent to the existing tower leg. The extended length reinforcing leg would be attached to the existing tower leg at regularly spaced points, or as needed, using U-bolts, rear brackets, etc., as needed or desired.

[0018] Further, in one or more other exemplary embodiments, some or all of the reinforcing legs may not include bearing plates. For example, individual reinforcing legs may comprise lengths of channeled material, such as lengths of bent or angled plate material (e.g., lengths of angled steel). A desired number of these reinforcing leg sections could then be placed end-to-end in consecutive fashion along an existing tower leg to create an extended length reinforcing leg of the desired length. Rather than relying on abutting bearing plates, these consecutive leg sections may be joined together through the use of the earlier mentioned bridging members, for example. The extended reinforcing leg could then be clamped, bolted or otherwise fastened to the existing tower leg at one or more points. Corresponding lengths of the other tower legs could be reinforced in like manner and the reinforcing legs would then be tied together to form a reinforcing assembly around the existing tower.

[0019] On that point, those skilled in the art should realize that reinforcing legs can be attached anywhere along the existing tower. For example, to reinforce only a portion of the existing tower, the exemplary reinforcing assembly comprises a reinforcing leg of the desired length (comprising one continuous section or two or more joined sections) for each tower leg to be reinforced. After attaching the reinforcing legs to the existing tower legs, the reinforcing legs themselves are interconnected together. As noted before, this configuration effectively forms a new tower that surrounds and reinforces at least a portion of the existing tower.

[0020] Of course, those skilled in the art should appreciate that the foregoing information summarizes exemplary details of the present invention and, as such, should not be construed as limiting the present invention. Indeed, those skilled in the art will recognize other advantages and

features of the present invention upon reading the following descriptions and viewing the accompanying illustrations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Fig. 1 is a diagram of a typical guyed tower.

Fig. 2 is a diagram of a typical tower leg section joint detail.

Fig. 3 is a diagram of typical tower cross section.

Fig. 4 is a diagram of an exemplary reinforcing assembly according to one embodiment of the present invention.

Fig. 5A-6F are diagrams of exemplary details for one or more embodiments of the reinforcing legs included in an exemplary tower reinforcing assembly according to the present invention.

Figs. 6A-6C and 7A-7F are diagrams of exemplary details for one or more embodiments of the braces included in an exemplary tower reinforcing assembly according to the present invention.

Fig. 8A is an exploded view diagram of an exemplary combination of reinforcing legs and braces for reinforcing selected sections of an existing tower.

Fig. 8B is a diagram of the reinforcing legs and braces introduced in Fig. 7A after mounting to the existing tower in accordance with an exemplary reinforcing method of the present invention.

Figs. 9A-9C are diagrams of dimensional details for the leg reinforcing members and braces in an exemplary embodiment of the present invention.

Fig. 10 is a diagram in plan view that illustrates how the reinforcing assembly of the present invention forms a structural network that surrounds at least a portion of the existing tower structure.

Fig. 11 is a diagram of an exemplary reinforcing leg that includes the bridging connectors illustrated in Fig. 4B for bypassing an existing obstacle on a tower leg.

Figs. 12A and 12B are diagrams of a reinforcing leg section that includes an exemplary guy pull-off for mounting a guy wire to the reinforcing leg rather than to the existing tower leg.

Figs. 13A and 13B are diagrams of an exemplary back plate that may be used to reinforce accessory mounts on a reinforcing leg.

Figs. 14-17 are diagrams of exemplary boom gate mounts that may be used to relocate existing boom gates from existing tower legs to newly added reinforcing legs.

Figs. 18 and 19 are diagrams of exemplary details for an exemplary bottom kit, which may be included in one or more embodiments of the reinforcing assembly of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0022] While the present invention is applicable to a range of structural tower types, Fig. 1 illustrates an exemplary guyed tower 10, which may be reinforced using one or more exemplary embodiments of a reinforcing assembly according to the present invention. In a typical implementation, tower 10 comprises a base section 12-1 pivotally mounted to a base plate, wherein the base section 12-1 supports one or more vertically stacked tower sections 14 (e.g. 14-1, 14-2,...14-N). Each tower section 14 comprises a series of legs with adjacent tower sections joined together at section joints 16. Further, each section 14 typically includes bracing 18 to reinforce the tower legs in that section against bending and twisting forces.

[0023] As shown, tower 10 includes a number of guy pull-offs 20 that typically are integrally attached at calculated points along the tower's legs. Guy wires 21 are attached to each of the guy pull-offs 20, and the proper tension is placed on the set of guy wires 21 to ensure tower stability. Properly tensioning the guy wires 21 places potentially significant compressive loads on the tower 10. Additional guy wires may be attached to "torque arms" (not shown), which attach to tower 10 and provide cantilevered arms projecting outward from tower 10 that may be used to adjust torsion within the tower structure.

[0024] In addition to the guy pull-offs 20, Fig. 1 depicts a number of tower appurtenance mounts 22 used to mount a variety of appurtenances to one or more of the tower legs. In the context of this discussion, the term "appurtenance" is given broad construction and includes a range of equipment and accessory types and thus includes essentially anything mounted along the length of tower 10.

While different types of appurtenances may use different mount types, all such appurtenances generally somehow attach to the legs and/or bracing of the existing tower 10 and thus are generically referred to as appurtenance mounts 22.

[0025] In the diagram, then, antennas A1-A4 are mounted to tower legs within various sections 14 of the tower 10 using one or more varieties of appurtenance mounts 22. For example, the appurtenance mounts 22 may comprise so-called "boom gate mounts," which are used to attach antenna boom arms (such as those illustrated for antenna A4) to one or more tower legs.

[0026] Fig. 2 shows exemplary details for a typical tower leg section joint 16. As shown, section joints 16 between adjacent sections 14 of tower 10 comprise, for each tower leg 30, a pair of abutting tower leg flanges 32. That is, each leg section 30 includes a pair of tower leg flanges 32, one at each section end, such that consecutive leg sections 30 may be bolted together at each section joint 16. An exemplary leg flange 32 includes a number of holes that align with holes in the abutting leg flange 32 such that the abutting leg flanges 32 may be bolted together using flange bolts 34.

[0027] With the above arrangement, tower sections 14 may be stacked one over the other, with each section 14 bolted together with the immediately preceding and succeeding adjacent sections 14 to form the overall tower 10. Fig. 3 illustrates one tower section 14 in a cross sectional plan view that better depicts the exemplary, stackable tower section configuration. The illustrated cross section depicts tower leg sections 30-1, 30-2 and 30-3 in an equilateral triangle arrangement and interconnected by braces 18, which may be integrally attached to legs 30 or which may be removeably fastened to legs 30.

[0028] Note that the illustrated triangular cross section is typical of structural guyed towers. For example, Rohn Industries, Inc., which maintains a business address of 6718 West Plank Road, Peoria, IL 61604, manufactures and sells the widely used ROHN 80/90 SERIES of guyed towers. One or more of the embodiments of the present invention as described and illustrated herein represent exemplary configurations for reinforcing a typical ROHN 80 SERIES tower. However, the illustrated and described embodiments should not be construed as limiting the present invention in

any way, and should be understood as merely offering exemplary details for a typical tower configuration.

[0029] Broadly, the present invention comprises a reinforcing assembly and method that may be used to reinforce one or more sections of an existing tower that includes one or more legs, and which may or may not include existing bracing, or flanged connections. In one or more exemplary embodiments, the reinforcing assembly of the present invention may be used to reinforce one or more sections 14 of the existing tower 10.

[0030] Fig. 4 depicts an exemplary reinforcing assembly 42 that includes a plurality of reinforcing legs 42, and may include a plurality of braces 44. Braces 44 add additional structural reinforcing by attaching to and interconnecting respective pairs of reinforcing legs 42 once the reinforcing legs 42 are mounted to corresponding ones of the tower legs 30. In an exemplary configuration, the reinforcing assembly 42 includes a set of reinforcing legs 42 and braces 44 for each tower section 14 to be reinforced. As will be detailed herein, the reinforcing assembly 42 may include variously modified reinforcing legs 42 to accommodate specific structural details of tower 10, and may include additional components, accessories, etc., as needed or desired.

[0031] Figs. 5A-5F illustrate exemplary details for one or more embodiments of the reinforcing legs 42. In particular, Fig. 5A illustrates an exemplary embodiment of a reinforcing leg 42, which is configured for mounting adjacent to an existing tower leg section 30 such that it is interposed between a pair of section joints 16 along a given leg of the existing tower 10.

[0032] As illustrated, reinforcing leg 42 includes one or more rigid leg sections 46, which interconnect a pair of bearing plates 48 fixed at either end of reinforcing leg 42. The bearing plates 48 are configured for attachment to tower leg flanges 32, such that each reinforcing leg 42 may be mounted adjacent to a corresponding tower leg section 30 such that it is interposed between the section joints 16 defining that tower leg section 30.

[0033] In the illustrated embodiment, reinforcing leg 42 includes two leg sections, 46-1 and 46-2, joined together at a shim joint formed by abutting section plates 50. By including one or more shim joints along the length of reinforcing leg 42, its overall length may be adjusted by the insertion

of one or more shim plates 51 of varying thickness. In this manner, the overall end-to-end length of reinforcing leg 42 may be adjusted to accommodate variations in the joint-to-joint spacing of a given tower leg section 30. That is, each reinforcing leg 42 may be shimmed such that each of its end bearing plates 48 engages with the corresponding leg flange 32 at opposing section joints 16 of a given tower leg section 30.

[0034] Each bearing plate 48 is fixed to one end of a reinforcing leg 42. In an exemplary embodiment a bearing plate 48 is welded to each end of the reinforcing leg 42. As illustrated, the bearing plates 48 each include a receiving slot or cutout for at least partially receiving a given one of the tower legs 30. Similarly, the leg sections 46 comprise channeled members that include an interior angled channel having a channel depth substantially the same as the receiving slot of the end bearing plates. In this manner, each reinforcing leg 42 at least partially wraps around an existing tower leg 30 and allows the bearing plates 48 to slide onto the respective tower leg flanges 32. The interior angle and any included radius of curvature of the channel may be set or configured as needed or desired.

[0035] Complementing this arrangement, each bearing plate 48 includes one or more mounting holes that align with existing holes in the tower leg flanges 32, if present, such that the bearing plates 48 may be bolted together with the tower leg flanges 32 at given ones of the section joints 16. Details of this mounting arrangement are discussed later herein. However, as noted earlier herein, reinforcing legs 42 may be used to reinforce non-sectioned and/or non-flanged tower legs and, thus, it should be understood that bolting bearing plates 48 together with tower leg flanges 32 represents an exemplary but non-limiting mounting arrangement.

[0036] Fig. 5B shows an exemplary adaptation that may be used as needed or desired where given ones of the reinforcing legs 42 are to be mounted to tower leg sections 30 that include one or more obstacles that cannot be removed or relocated. Thus, in one embodiment a given portion of a leg section 46 is removed to create a gap sufficient to accommodate the obstacle to be bypassed. Bridging members 52 then are used to bridge the gap and interconnect the separated leg sections 46 by mounting along the sides of leg sections 46. The illustrated arrangement depicts the bridging

members 52 fastened on either side of the separated leg sections 42 to maintain rigid connectivity between the separated leg sections 46 while still providing an opening to accommodate the tower leg obstacle. As shown, the opposing sides of the exemplary leg section(s) 46 in each reinforcing leg 42 provide flat, outer mounting faces, which may include one or more rows of regularly spaced apart mounting holes for convenient attachment of bridging members 52, as well as other accessories (mounts, etc.). Note that a reinforcing leg 42 may be made an arbitrary length by varying the number and lengths of leg sections 46. That is, a reinforcing leg 42 may be made from a plurality of leg sections 46, potentially of varying section lengths, with the number and length of sections 46 chosen to arrive at the desired length of reinforcing leg 42.

[0037] The leg opening is more clearly shown in Fig. 5C, and that depiction further illustrates that the bridging members 52 may be mounted on the inside mounting faces of leg sections 46 or on the outside mounting faces. Additionally, those skilled in the art should appreciate that the bridging members 52 may be made of flat elongated plate material, ribbed plate material, angled plate material, or other material as needed or desired depending upon, for example, the required rigidity and bending strength.

[0038] In one or more exemplary embodiments, one or more of the reinforcing legs 42 used in a particular tower reinforcing application may omit one or both of the end bearing plates 48. In such embodiments, reinforcing legs 42 may be made by placing leg sections 46 end-to-end and joining them together, such as with bridging members 52. Again, arbitrary length reinforcing legs 42 may be made in this fashion.

[0039] Fig. 5D shows and exemplary alternate embodiment for a given portion of leg section 46. Here, instead of completely separating leg sections 46 to create a gap, a slotted cutout 53 is formed at the required location along a leg section 46. This slotted cutout may be used to allow an existing obstacle to project through the slotted opening 53 to thereby avoid any mechanical interference. By including the slot which extends from a mounting face edge of leg section 46 into an interior opening, the leg section 46 may be positioned onto a guy wire 21 and slid into position onto an existing tower leg 30 such that a preexisting guy pull-off 20 projects through the slotted opening 53.

Note that a bridging member 52 may be installed across the slot at the mounting edge of leg section 46 to provide reinforcement as needed or desired.

[0040] Figs. 5E and 5F illustrate exemplary details for the bearing plates 48 and the section plates 50, respectively. As noted, reinforcing leg sections 46 may include one or more shim joints comprising formed by abutting section plates 50. In an exemplary embodiment, bearing plates 48 are configured generally to the shape of match tower leg flanges 32, while the section plates 50 may be shaped as needed or desired. (Here, the bearing plates 48 comprise rectangular plates, while the mid-section plates 50 comprise rounded or elliptical plates.) It should be understood that such details are not limiting and may be varied as needed or desired. The need for shim joints in the reinforcing legs 42 may be driven, for example, by installations where the reinforcing legs 42 include end bearing plates 48 that preferably "fit" snugly between tower leg flanges 32 at opposing section joints 16 of a given tower leg section.

[0041] Figs. 6A-6C illustrate exemplary configurations for the one or more braces 44, which may be used to interconnect and reinforced mounted pairs of reinforcing legs 42. Braces 44 may be formed as individual cross-sections (1x) as shown in Fig. 6A, or in assemblies of two or more cross sections (2x, 3x, etc.) as shown in Figs. 6B and 6C. In an exemplary configuration, the braces 44 are formed from solid rods, which are flattened at crossover points 60 and at end points 64. The flattened areas may be pre-dilled for convenient attachment to the mounting faces of reinforcing legs 42.

[0042] Also note that each brace 44 may include adjustable-length bracing members, which may be implemented using turnbuckles (sleeve nuts) 52. In an exemplary sleeve nut implementation, cross brace members are separated at joined threaded ends such that the sleeve nut may be rotated to adjust the cross bracing span of brace 44 to accommodate variations in the span distance between pairs of mounted reinforcing legs 42. Selected exemplary brace details are illustrated in Figs. 7A-7F. As before, it should be understood that these details are exemplary rather than limiting.

[0043] Turning now to an exemplary tower reinforcing method in accordance with the present invention, Fig. 8A depicts a series of consecutive tower leg sections 30 spanning three sections 14 of tower 10. Note that for clarity of illustration, the pre-existing tower braces 18 running between tower leg sections 30 are not shown. As illustrated, leg section 30-1 is coupled to leg section 30-2 at an upper section joint 16 comprising abutting leg flanges 32 of each leg section 30. Similarly, leg section 30-1 is coupled to leg section 30-3 at a lower section joint 16 of abutting tower leg flanges 32. Similarly inter-section couplings are depicted for the remaining tower leg sections 30-4 through 30-9.

[0044] According to an exemplary reinforcing method, a reinforcing leg 42 is placed adjacent to each tower leg section 30 and mounted to the opposing pair of section joints 16 for that tower leg section 30. In this manner, each reinforcing leg 42 is interposed between the sections joints 16 of the leg section 30 to which it is mounted and, with this mounting configuration, shares compressive and other loads (e.g., bending) with the adjacent leg section 30. Thus, reinforcing leg 40-1 attaches to the opposing leg flanges 32 of leg section 30-1, reinforcing leg 40-2 attaches to the opposing leg flanges 32 of leg section 30-2, and so on. Once the reinforcing legs 42 are mounted around one section 14 of the tower 10, braces 44 may be attached to respective pairs of reinforcing legs 42 on each "face" of the tower.

[0045] With the above exemplary configuration, consecutive reinforcing legs 42 mounted to consecutive tower leg sections 30 bolt together through the included section joints 16 by attaching on either side of section joint 16. That is, the lower bearing plate 48 of reinforcing leg 42-1 bolts to the top of the lower leg flange 32 of tower leg section 30-1 and the top bearing plate 48 of reinforcing leg 42-3 bolts to the underside of the abutting tower leg flange 32 of tower leg section 30-3.

[0046] Thus, the section joint 16 comprising the aforementioned abutting tower leg flanges 32 may be partially unbolted such that bearing plates 48 from leg sections 42-1 and 42-3 may be positioned on either side of the respective section joint 16 and the entire assembly, including the included leg flanges 32 and respective bearing plates 48, bolted together again.

[0047] The reinforcing assembly 40 thus allows adding reinforcing legs 42 to consecutive tower leg sections 30 without relieving the tower loads from the leg sections 30 being reinforced. This operation may be better understood referring back to bearing plate details illustrated in Figs. 5A and 5E. In those illustrations, one notes that bearing plates 48 include receiving slots which allow the bearing plates 48 to fit around the curvature of tower legs 30 to thereby cover one or more but not all of the existing flange bolts included at the section joints 16. That is, an installer may remove flange bolts from the tower leg flanges 32 corresponding to the mounting holes in the bearing plates 48 while leaving installed one or more remaining flange bolts. Thus, reinforcing legs 42 may be installed without completely unbolting any of the section joints 16 along the tower leg sections 30.

[0048] Fig. 8B depicts the same three sections 14 of tower 10 after reinforcing. The assembled configuration clearly depicts the revised section joints 16 of the reinforced tower sections 16, which now include the bearing plates 48 at respective ends of mounted reinforcing legs 42 bolted together with the pre-existing tower leg flanges 32. With this arrangement, tower loads transferred along successive tower leg sections 30 through the included section joints 16 are shared by and similarly transferred along successive reinforcing legs 42. As such, the tower's ability to withstand significantly increased compressive, bending, and torsion loads may be greatly increased. Such increases permit the existing tower 10 to carry added service provider equipment and/or to meet increased safety requirements.

[0049] In a similar but simplified depiction, Figs. 9A and 9B illustrates a side view of one tower section before and after reinforcement. Note that the dimensional information depicted on the illustrations corresponds to an exemplary configuration for a ROHN 80 SERIES tower. As such, any and all such dimensions may be altered as needed or desired to accommodate other types or models of tower. Fig. 9C also illustrates that the braces 44 may be configured as pre-assembled bracing sections, e.g., 44-1, 44-2, for convenient hoisting and attachment to mounted reinforcing legs 42. Those skilled in the art will appreciate that the remaining tower faces will include like pairs of reinforcing legs 42 interconnected by like braces 44.

[0050] Fig. 10 depicts a cross section of a reinforced tower section 14. With this view, one sees that, in one or more exemplary embodiments, the reinforcing assembly 40 of the present invention forms a surrounding structural network around the existing tower section 14. Note that braces 44 may be attached to mounting faces of the reinforcing legs 42 using bolts 60, and that the crossover points 60 of each brace may be bolted together using bolts 62, which may or may not be sized the same as bolts 60.

[0051] Effectively, the reinforcing assembly 40 forms a "tower around a tower" inasmuch as it provides reinforcing legs 42 running along and strategically interconnected with each of the existing tower legs, such that reinforcing legs 42 share tower loads with the existing tower legs. Of course, the reinforcing structural network of assembly 40 may be extended around a single section 14 of the existing tower 10, around multiple consecutive or non-consecutive sections 14 of tower 10 as needed or desired, or around the entire tower 10. Thus, while a typical installation involves reinforcing all sections 14 of tower 10 to increase the overall structural strength of tower 10, it may be that only selected sections 14 of the tower 10 need reinforcing.

[0052] One point that may be noted in particular in Fig. 10 is that the reinforcing leg sections 46 may be made from bent or angled plate material, such as steel plate of a desired thickness. As can be seen, then, the cross-sectional area of the reinforcing leg sections 46 may be appreciably greater than the cross sectional area of the existing tower legs 30. Thus, the thickness and width (edge-to-edge distance) of the reinforcing legs 46 may be adjusted as needed or desired to obtain the desired structural strength, rigidity, etc. The load capability of the existing tower thus may be dramatically increased using the present invention's reinforcing assembly 40.

[0053] Those skilled in the art should recognize that the exemplary assemblies (and assembly methods) illustrated in, for example, Figs. 8A and 8B, are not limiting. That is, the reinforcing legs 42 are not necessarily mounted to tower leg flanges 32. For example, the reinforcing assembly 40 may be used to reinforce non-sectioned tower legs. Referring back to Fig. 8A, and assuming that the individual reinforcing legs 42 are shorter than the length of tower leg to be reinforced, one sees that consecutive reinforcing legs 42 may be positioned along a desired length of non-section tower

leg 30 to form an "extended length" reinforcing leg of a desired length. These individual reinforcing legs 42 may be interconnected together at their abutting bearing plates 48 without any interposed tower leg flanges 32, and different length reinforcing legs 42 may be combined to arrive at the desired overall extended length. Of course, as noted, an arbitrary length reinforcing leg 42 may be formed without the use of abutting bearing plates simply by interconnecting two or more reinforcing leg sections 46 together through the use of bridging members 52 or some other interconnection mechanism.

[0054] Turning back to specific details of exemplary reinforcing legs 42, Fig. 11 illustrates the use of bridging members 52 to join separated sections 46 of a reinforcing leg 42 such that a gap is created to accommodate an existing obstacle along a tower leg 30. Specifically, Fig. 11 illustrates the use of such bridging members 52 to bypass a pre-existing guy pull-off 20 that is integrally connected to an outer face of a tower leg 30.

[0055] Rather than removing the guy pull-off 20, which would require extensive work (and potential danger) associated with detaching and then later reconnecting the associated guy wire 21, the corresponding reinforcing leg 42 simply may be adjusted to include a gap sufficient to clear the guy pull-off 20, and the gap may be bridged on either side of the tower leg 30 by attaching bridging members 52 to the mounting faces of the reinforcing leg sections 46 that run along either side of the existing tower leg 30.

[0056] Alternatively, or in addition to bypassing existing guy pull-offs 20, the reinforcing legs 42 may be used to add or replace guy pull-offs on tower 10, as shown in Figs. 12A and 12B. Specifically, Figs. 12A and 12B provide plan and side views, respectively, of an exemplary leg section 46 that includes a guy pull-off 80, which may be welded to the outer face of the leg section 46, for example. This leg section 46 thus may be placed along a tower leg 30 at a point where the guy pull-off is needed and interconnected with adjacent leg sections 46 using bridging members 52. Note that, here, the bridging members 52 are illustrated as lengths of angled or bent-plate material rather than the earlier illustrated flat plate material. Regardless, the guy pull-off 80 permits new or preexisting guy wires 21 to the reinforcing leg 42 rather than to the existing tower leg 30.

[0057] Indeed, many different types of new or preexisting tower appurtenances may be mounted to the reinforcing legs 42 rather than to the existing tower legs 30. In support of this, an exemplary reinforcing assembly 40 may include one or more additional accessory mounts that are configured integral with or mountable to reinforcing leg sections 46. Indeed, the exemplary rows of mounting holes running along the mounting faces of the reinforcing legs 42 provide for convenient attachment of many different accessories, mounts, etc.

[0058] Figs. 13A and 13B illustrate exemplary details for an attachment plate 84 which may be positioned on a back side of an existing tower leg 30 and aligned with mounting holes in a reinforcing leg 2 such that an accessory mount attached to an outer face of the reinforcing leg may be further reinforced from behind. Thus, mounting bolts 86 may be used to pass through each side of the leg section 42

[0059] Figs. 14 and 15 and 14 show side and plan views, respectively, of another accessory mount which may be used to relocate existing tower appurtenances, e.g., antennas, etc., from the existing tower legs 30 to the newly mounted reinforcing legs 42. As depicted, an exemplary boom gate mount 90 includes mounting plates 92 that are interconnected with a vertical pole sleeve 94. The mounting plates 92 extend on either side of a reinforcing leg 42 such that the mounting plates 92 may be bolted to mounting faces of a reinforcing leg section 46. A mounting pole 96 may be inserted through the pole sleeve 94 to provide a vertical mounting pole running adjacent to the existing tower leg 30 and reinforcing leg 42. Note that a pair of boom gate mounts 90 may be installed to secure upper and lower ends of the mounting pole 96 for enhanced mounting strength. Thus, the accessory mounts 22 used to attach the boom gates of the antennas 1-4 illustrated in Fig. 1 on the existing tower 10, for example, may be relocated to the newly added pole 96. Figs. 16 and 17 illustrate an exemplary alternate embodiment for the boom gate mount 90.

[0060] In this manner, antenna boom gate mounts and other antenna accessories may be conveniently detached from the existing tower legs 30 before installation of a reinforcing leg 42, and the previously detached accessories then reconnected to the reinforcing leg 42 rather than to the existing tower leg 30. Similarly, existing feed line brackets, etc., may be partially or completely

detached from the existing tower 10 to allow installation of the reinforcing assembly 40 and then reattached to the mounted reinforcing assembly 40.

[0061] Indeed, one of the many advantages of the present invention is that some or all of the tower appurtenances may be relocated from the existing tower 10 to the reinforcing assembly 40. In so doing, an installation crew may incrementally detach and reattach various mounts, brackets, etc. as the crew advances along the length of tower 10.

[0062] Finally, in introducing an exemplary existing tower 10 in Fig. 1, it was noted that such towers may include a base section configured as an inverted triangle, pyramid, etc. In Fig. 1, 12-1 comprised such a base section. In adding the reinforcing legs 42 and braces 44 of the present invention, it may be appreciated that significant additional weight potentially is added to the existing tower 10. Indeed, depending on the number of tower sections 14 being reinforced, it may be necessary to upgrade the base section 12 of the tower 10, and even the underlying foundation and surrounding soil, as will be well understood by those skilled in the art.

[0063] Figs. 18 and 19 depict exemplary details for a "bottom" kit, which may be included as needed in the reinforcing assembly 40 of the present invention. As illustrated, an angled base reinforcing leg 102 is included for each existing leg in the tower base 12. The exemplary bottom kit further includes additional bracing members 106 and 108 to interconnect the base reinforcing legs 102.

[0064] Each base reinforcing leg 102 includes at its top end a base flange 104 to couple with the bearing flange 48 of a corresponding one of the reinforcing legs 42 mounted to a leg of the bottom most existing tower section 14. Note that, if desired, the bearing plates 48 of the reinforcing legs 42 that interconnect with the base reinforcing legs 102 may be made larger to provide more abutting surface area with the base flanges 104.

[0065] The base reinforcing legs 102 angle downward toward the existing tower base plate 110 on which the existing tower base legs 112 are terminated, or which otherwise surrounds the existing tower base legs 112. Note that these tower base legs 112 interconnect with and bear loads transferred through the corresponding tower legs 30 in the bottom most tower section 14. As

illustrated, the exemplary base reinforcing legs 102 abut together edgewise, essentially forming a reinforcing perimeter around the existing tower base legs 112. This arrangement conforms to the base plate perimeter and permits the shared loads transferred down through the reinforcing assembly 40 to be coupled into the existing base plate 110. Typically, such base plates are engineered such that the additional loading of the reinforcing assembly 40 is easily handled although, as noted, the underlying tower foundation may need to be upgraded.

[0066] Those skilled in the art will appreciate that the above details are, as noted, exemplary. The present invention broadly comprises a reinforcing assembly 40 that surrounds and reinforces at least a portion of an existing tower 10. Reinforcing legs 42 included in the reinforcing assembly mount adjacent to and reinforce existing tower legs. In one or more exemplary embodiments, the reinforcing legs 42 attach to pairs of section joints 16 along consecutive tower leg sections 30 such that the reinforcing legs 42 generally are interposed between pairs of section joints such that each reinforcing leg 42 shares tower loads with a corresponding tower leg. As noted, however, the reinforcing legs 42 may be used on non-sectioned or non-flanged tower legs, in which case, the bearing plates 48 of the reinforcing legs 42 are not attached to tower leg flanges 32. For example, attachment plates 84 or other attachment fixtures may be used as needed or desired to secure reinforcing legs 42 to the existing tower legs.

[0067] The tower 10 may include one, two, three, or more legs, and may include one, two, or more stacked tower sections 14. The sections 14 may be uniform (same length, same leg dimensions, etc.) or the sections 14 may be different. For example, towers 10 commonly include differently dimensioned or configured dimensions at different tower elevations, e.g., lighter sections 14 at upper tower elevations, and heavier, larger sections 14 at lower tower elevations. It should be understood, then, that the reinforcing assembly 40 of the present invention may include differently sized or configured reinforcing legs 42, braces 44, etc., corresponding to the different tower sections 14 used at a particular site.

[0068] Thus, the present invention is not limited by the above exemplary details. Indeed, the present invention is limited only by the following claims and their reasonable equivalents.